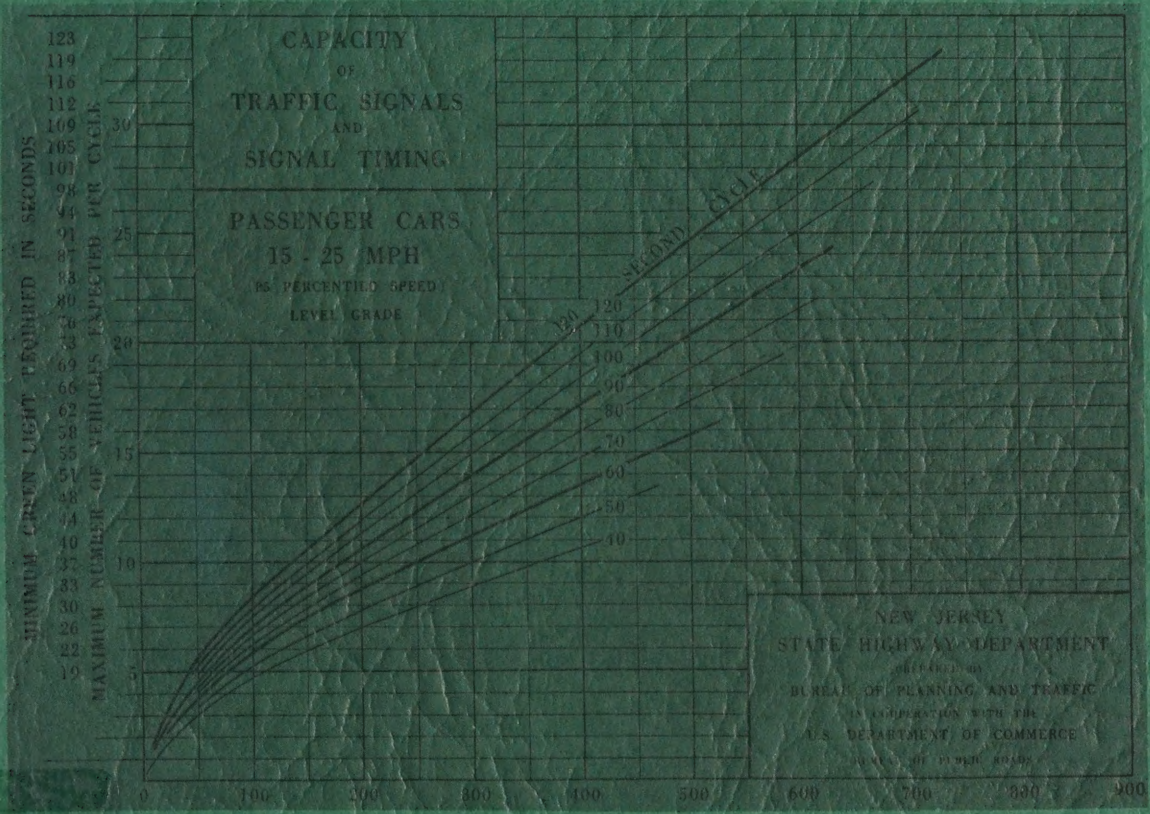
CAPACITY OF TRAFFIC SIGNALS AND TRAFFIC SIGNAL TIMING



PRESENTED AT HIGHWAY RESEARCH BOARD JANUARY 1960

NEW JERSEY
STATE HIGHWAY DEPARTMENT
PREPARED BY
BUREAU OF PLANNING AND TRAFFIC
IN COOPERATION WITH THE
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

Traffic, Analysis
Traffic Control, Signal Systems
Sign, Signal + Markings

CAPACITY OF TRAFFIC SIGNALS
AND
TRAFFIC SIGNAL TIMING

A PAPER
PRESENTED AT
THE 39th ANNUAL MEETING OF THE
HIGHWAY RESEARCH BOARD
WASHINGTON D. C.
JANUARY 1960

BY

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BUREAU OF PLANNING & TRAFFIC

Similar conditions on a road produce similar behavior among motor vehicle users of that road. The principal research problem is to recognize and isolate the conditions and then measure traffic behavior under these conditions. Having done this for a sufficient number of varying conditions, practical application can be made covering other varying but similar conditions.

Although traffic on the open road may travel at random, traffic signals regiment this traffic into narrow bands of variation.

The behavior of vehicles responding to the green signal, after waiting during the red signal, can be described by:

$$T = PN + \frac{K}{S} \sqrt{\left\{D + C(N-1)\right\} \left\{D + C(N-1) + \frac{S^2}{4}\right\}}$$

where T = Time in seconds, after the beginning of the green signal, to arrive at the distance D

T_p Time for passengers cars

T_t Time for trucks

P = Perception and reaction time in seconds

N = Nth vehicle stopped in line (single line)

K = Constant of acceleration

S = Speed limit (real) in miles per hour

D = Distance in feet measured from the stop line of the first car

C = Spacing in feet measured front to front of standing vehicles

The perception and reaction time (P) for the first car is the time between the beginning of the green signal and the beginning of the vehicles forward motion. It includes the time for the first driver in line to perceive that the signal has turned green, the mental and physical reaction time of the driver to start the vehicle in motion and the time for the mechanics of the vehicle to overcome inertia. The perception and reaction time for other drivers following is similar except that each driver must perceive that the vehicle immediately ahead has started its forward motion rather than perceive that the signal has turned green.

The constant (K) varies with the acceleration capabilities of the vehicle, within the desirable limits of the driver. Passenger car drivers seldom exercise the maximum or close to maximum capability of the vehicle.

The speed limit (S) is that speed limit which is reasonable. Where the posted speed limit is based on the 85 percentile method this speed limit is (S) but where the posted speed limit is higher or lower than the 85 percentile, the 85 percentile is used.

COMPARISON OF ACCELERATION EQUATION WITH FIELD DATA

Table 1 and Figure 1 show a comparison of field data with calculated data on Route U. S. 1, southbound at Avenel Street, Woodbridge, New Jersey. Field data were collected by a five man party pressing telegraph keys wired to an Esterline –Angus 20 pen recorder during the summer of 1958. Route U. S. 1 has 37,000 cars per average day with 10% heavy trucks and 25% total trucks. The posted speed limit is 50 miles per hour for 8 miles to the south and 1.5 miles to the north. Beyond these points the posted speed limit is 45 miles per hour. The highway is level and tangent with 32 feet of concrete pavement on each side of a 16 foot raised median. The pavement is lane lined for three lanes in each direction. There are very few pedestrians but some marginal friction exists because of frequent gas stations and such. Data collected were for passenger cars in the left hand lane.

Field data shown are the average time for the number of samples; that is the sum of the individual times divided by the number of samples.

A frequency speed diagram is shown in Figure 2.

For 100% passenger cars not affected by turning vehicles, the perception and reaction time (P) is found, by experiment, to be 1.2 and to be the same for the Nth car as for the first car. This value is found to vary with the speed limit and to be different for trucks and passenger cars. For heavy trucks the value is 2.25.

The value for (K) for passenger cars is found to be 0.95 and for heavy trucks is found to be 1.32. These values satisfy the test samples observed. The passenger car value seems to be constant for all locations. This is probably true because there is very little difference in the average passenger car at different locations. If all passenger cars were small low priced cars, at one location, and large high priced cars, at another location, there probably would be a difference. The value for trucks undoubtedly varies from location to location. Predominantly loaded trucks will give a different value than unloaded trucks and there is a wide variation in performance ability of different makes and models of trucks.

The value of (C) for passenger cars is 25 feet. This consists of the length of the average passenger car measured from bumper to bumper plus the average spacing between standing vehicles measured from the rear bumper of one vehicle to the front bumper of the vehicle immediately in back. The length of the average passenger car is taken as 17 feet and the space between as 8 feet.

The (C) for heavy trucks is 50 feet for the Route U. S. 1 location and assumed to be the same for locations with similar types of trucks. The 50 feet is taken as composed of 42 feet for the length of vehicle and 8 feet for the space between vehicles. It is possible that this is in error in that the average heavy truck may be less than 42 feet long and the space between trucks may be longer than 8 feet.

Route U. S. 1 northbound, at Avenel Street, data are shown in Tables 2 A and 2 B and plotted in Figures 3 and 4. Samples selected from field data include only 100% samples. That is, the Nth truck was preceded by N–1 trucks. Passenger cars were selected similarly. Where the Nth vehicle was preceded by some trucks and some passenger cars, data were tabulated but not included in this part of the study.

Calhoun Street northbound, at Ingham Avenue, in Trenton, New Jersey, has one moving lane with parked vehicles along the curb. It is an urban location close to the central business district. The legal speed limit is 25 miles per hour. Comparative data are shown

The value (of K) for passenger cars is found to be 0.95 and for heavy trucks is found to be 1.22. These values satisfy the test samples observed. The passenger car value seems to be constant for all locations. This is probably true because there is very little difference in the average passenger car at different locations. If all passenger cars were small low priced cars at one location, and large high priced cars at another location there probably would be a difference. The value for trucks undoubtedly varies from location to location. Predominantly loaded trucks will give a different value than unloaded trucks and there is a wide variation in performance ability of different makes and models of trucks.

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Route U. S. 1 northbound at Avenel Street, data are shown in Tables 2A and 2B and plotted in Figures 3 and 4. Samples selected from field data include only 100% samples. That is, the Nth truck was preceded by N-1 trucks. Passenger cars were selected similarly. Where the Nth vehicle was preceded by some trucks and some passenger cars, data were tabulated but not included in this part of the study.

Calhoun Street northbound, at Ingham Avenue, in Trenton, New Jersey, has one moving lane with parked vehicles along the curb. It is an urban location close to the central business district. The legal speed limit is 25 miles per hour. Comparative data are shown

in Table 3 and Figure 5.

Brunswick Avenue southbound, at Olden Avenue, in Trenton, is an urban area similar to the Calhoun Street location. Comparative data are shown in Table 4 and Figure 6.

TRAFFIC SIGNAL CAPACITY AND SIGNAL TIMING

Free flowing traffic on an open highway has time intervals between successive vehicles which vary according to laws of probability. Figure 7 shows the maximum number of vehicles approaching in short time intervals for given hourly volumes of approach traffic based on Poisson's Theory of Probability. Part vehicles are dropped off and it is limited to one such hour. Theoretically a million such hours would give a larger maximum number per short time interval than that shown.

Figure 8 shows the number of seconds required to pass a given maximum number of vehicles per short time cycle in accelerating from a stopped position as occurs under traffic signal control. At a traffic signal the number of vehicles arriving during a traffic signal cycle of red, amber and green, must be passed during the green period of that cycle in order to avoid backing up and requiring vehicles to wait during more than one red period. This figure applies for uninterrupted passenger cars on a road where the real speed limit is 50 miles per hour. It can be used to determine the signal timing and cycle required for design hour volumes or to determine the capacity of a given cycle and timing.

A traffic signal can carry the maximum number of cars during each cycle which results in the absolute capacity but this occurs when the signal is greatly over-loaded and traffic is backed up for a long distance and vehicles must wait for many changes of signal before passing through. This is a degree of congestion to be avoided. The signal timing should be such that the maximum number of vehicles per cycle occurs only once during the design hour. This is the design capacity of the signal timing.

Figures 9, 10 and 11 show similar charts for use on 40, 30 and 20 mile per hour roads

for passenger cars on level grades and with normal daylight and weather conditions.

Figure 12 is a similar chart for heavy trucks on a 50 miles per hour road on level grades and with normal daylight and weather conditions.

These charts are developed from the use of the general acceleration equation quoted above with the following variables:

	S	P	K	C
Passenger Cars	50	1.2	0.95	25
" "	40	1.6	0.95	25
" "	30	2.0	0.95	25
" "	20	2.4	0.95	25
Heavy Trucks	50	2.25	1.32	50

On Figure 13 is shown the timing required for each of the above charts for ease of comparison of the effect of speed and vehicle type. Also included are cycle lengths up to 300 seconds. Some of this is extended beyond the limits of practical application but this is done for analytical purposes only. Certainly to have 70 heavy trucks in line go through a signal cannot be expected but this should have a bearing on possible application for a short cut method of signal timing on the bases of percentage of trucks to total hourly volume.

It is planned to continue this study to include the effect of upgrade, downgrade, night time and rainy weather.

It is also planned to extend this study to include the effect of closely spaced signalized locations, such as experienced in high type complex channelization.

RT. U.S. 1 S.B. AT AVENEL ST.

$$T_p = 1.2N + \frac{.95}{52} \sqrt{\left\{ D + 25(N-1) \right\} \left\{ D + 25(N-1) + 676 \right\}}$$

PASSENGER CARS

	D = 55 FEET				D = 381 FEET				D = 629 FEET			
N	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.
1	225	4.45	4.87	+.42	213	12.62	12.80	+.18	206	17.01	17.75	+.74
2	182	6.59	6.89	+.30	167	14.73	14.51	-.22	167	19.69	19.45	-.24
3	130	8.62	8.83	+.21	123	16.86	16.22	-.64	120	21.08	21.12	+.04
4	102	10.64	10.72	+.08	90	18.60	17.92	-.68	92	22.66	22.81	+.15
5	72	12.68	12.56	-.12	60	20.36	19.63	-.73	64	24.16	24.49	+.33
6	56	14.59	14.38	-.21	45	21.87	21.32	-.55	48	26.27	26.16	-.11
7	48	15.72	16.16	+.44	35	22.06	23.03	+.97	38	26.99	27.84	+.85
8	28	18.74	17.95	-.79	13	25.08	24.73	-.35	21	30.05	29.53	-.52
9	14	20.97	19.70	-1.27	5	26.60	26.40	-.20	11	31.93	31.22	-.71
10	8	23.58	21.45	-2.13	2	27.45	28.10	+.65	6	34.18	32.91	-1.27
11	6	25.53	23.19	-2.34	1	32.50	29.80	-2.70	4	36.53	34.59	-1.94
12	5	27.30	24.93	-2.37	1	32.50	31.49	-1.01	3	40.33	36.26	-4.07
13	7	28.01	26.67	-1.34					3	36.23	37.93	+1.70
14	6	29.73	28.38	-1.35					2	36.45	39.59	+3.14
15	4	32.05	30.09	-1.96								
16	4	35.05	31.80	-3.25								

TABLE 1

RT. U.S. 1 S.B. AT AVENEL ST. PASSENGER CARS

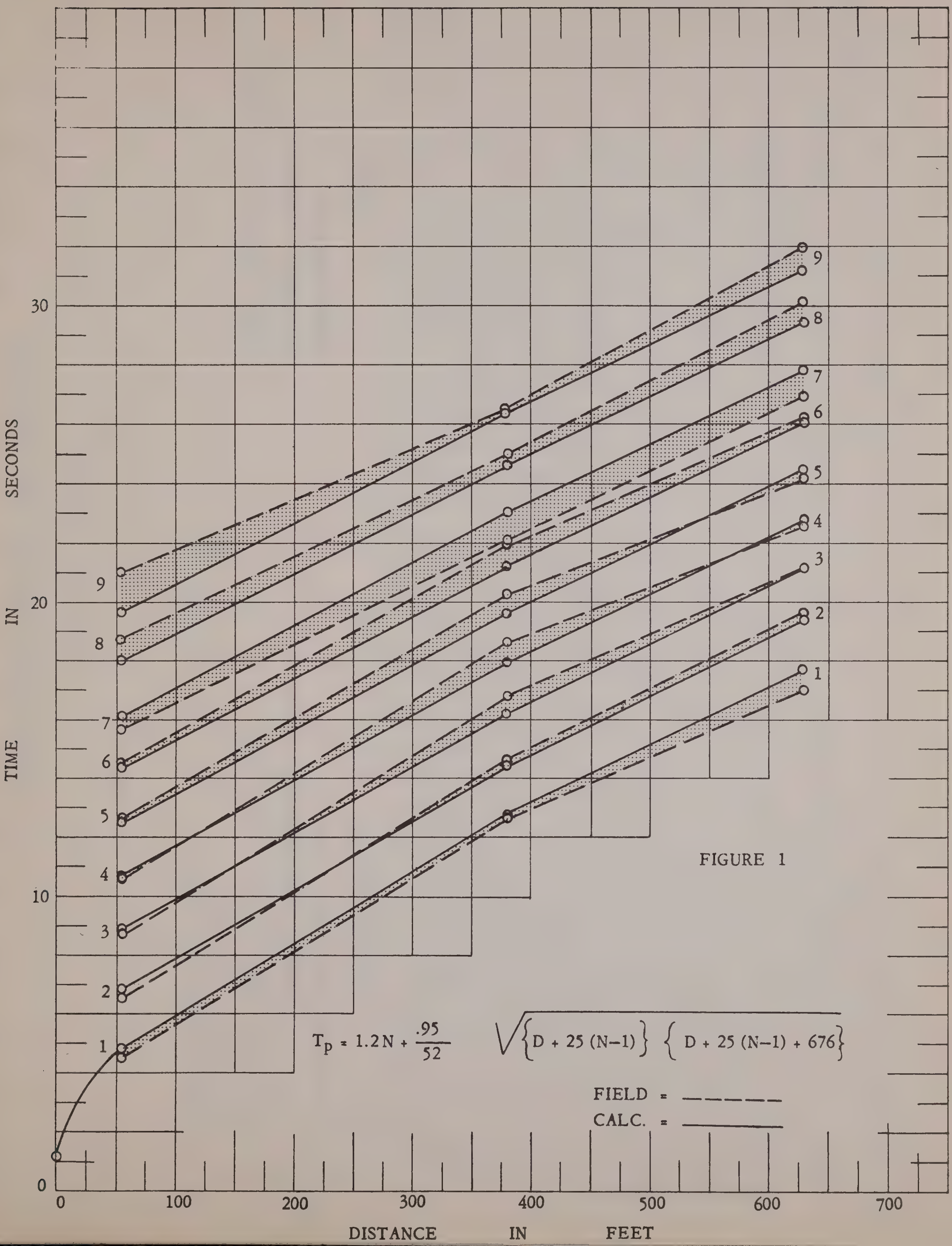


FIGURE 1

SMOOTHED FREQUENCY DIAGRAM

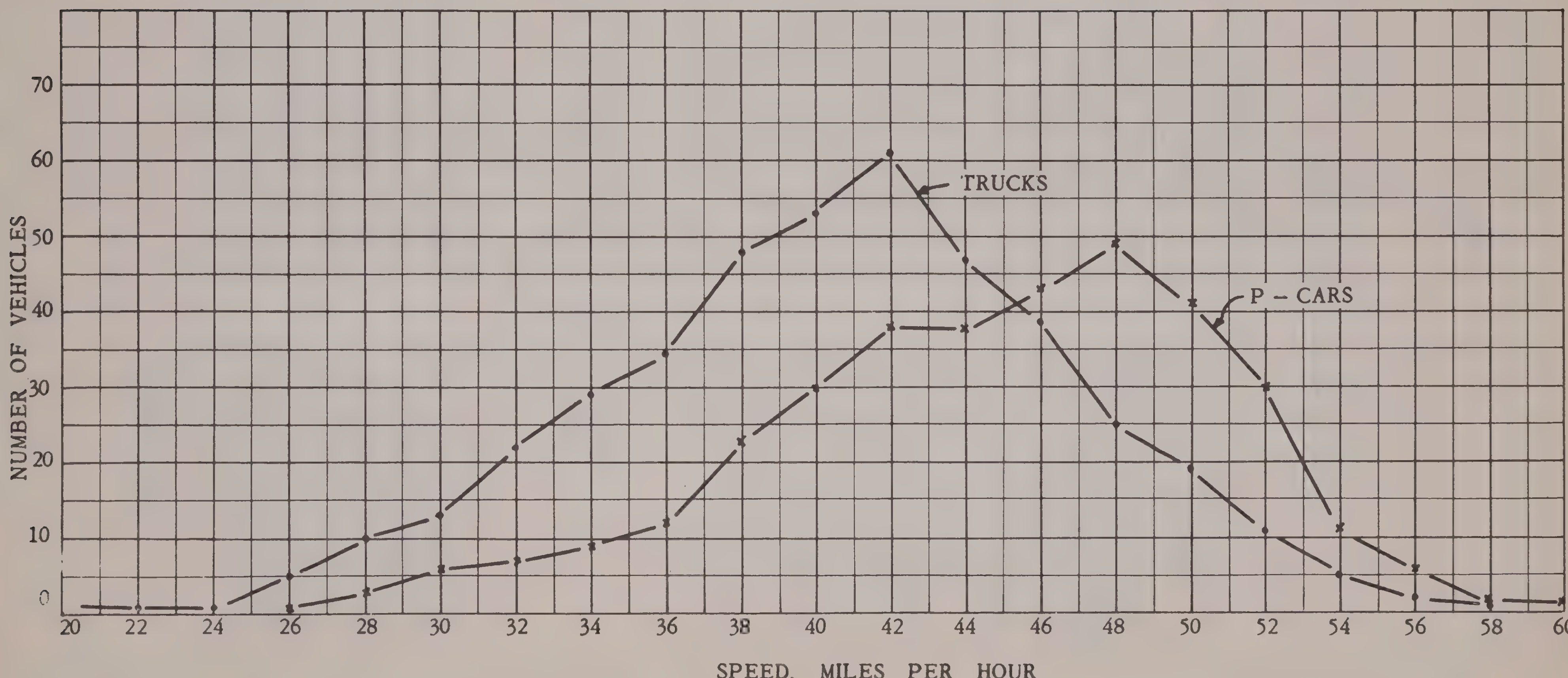
VEHICLE SPEEDS

ROUTE U.S. 1 N.B. AT AVENEL ST.

DATA RECORDED BY RADAR,
OCT. 10TH & 14TH, 1958
85% SPEED: FOR 432 P. CARS = 50 MPH
FOR 357 HEAVY TRUCKS = 46 MPH
AVG. SPEED: P-CARS 45 MPH
TRUCKS 41 MPH

CURVES SHOWN ARE SMOOTHED FREQUENCY: AVERAGE OF THREE INTERVALS

FIGURE 2



RT. U.S. 1 N.B. AT AVENEL ST.

$$T_p = 1.2N + \frac{.95}{48}\sqrt{\left\{D + 25(N-1)\right\}\left\{D + 25(N-1) + 576\right\}}$$

PASSENGER CARS

N	D = 52 FEET				D = 153 FEET				D = 222 FEET			
	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.
1	159	4.74	4.78	+.04	24	8.62	7.81	-.81	72	10.29	9.53	-.76
2	111	6.84	6.83	-.01	5	9.28	9.64	+.36	17	11.68	11.33	-.35
3	69	8.90	8.81	-.09					3	16.43	13.10	-3.33
4	46	10.63	10.72	+.09								
5	29	12.61	12.59	-.02								
6	17	14.18	14.42	+.24								
7	11	16.15	16.24	+.09								
8	11	18.02	18.05	+.03								
9	1	21.90	19.84	-2.06								
10	1	25.20	21.62	-3.58								
11	1	27.40	23.39	-4.01								

$$T_t = 2.25N + \frac{1.32}{48}\sqrt{\left\{D + 50(N-1)\right\}\left\{D + 50(N-1) + 576\right\}}$$

TRUCKS

1	117	6.38	7.23	+.85	32	10.89	11.45	+.56	103	13.59	13.83	+.24
2	63	10.88	11.74	+.86	17	14.95	15.39	+.44	60	18.02	17.70	-.32
3	28	14.97	15.91	+.94	10	18.83	19.34	+.51	32	21.72	21.55	-.17
4	14	19.00	19.89	+.89	5	22.90	23.19	+.29	16	25.86	25.34	-.52
5	6	23.33	23.79	+.46	3	26.20	26.99	+.79	8	29.52	29.10	-.42
6	3	26.83	27.65	+.82					2	33.05	32.82	-.23
7	3	30.63	31.65	+1.02								

TABLE 2A

RT. U.S. 1 N.B. AT AVENEL ST.

$$T_p = 1.2N + \frac{.95}{48}\sqrt{\left\{D + 25(N-1)\right\}\left\{D + 25(N-1) + 576\right\}}$$

PASSENGER CARS

N	D = 237 FEET				D = 471 FEET				D = 685 FEET			
	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.
1	110	10.00	9.89	-.11	155	15.00	15.09	+.09	19	19.77	19.59	-.18
2	90	12.08	11.68	-.40	96	16.98	16.83	-.15	5	24.36	21.32	-3.04
3	72	13.90	13.46	-.44	69	18.98	18.56	-.42				
4	52	15.63	15.21	-.42	49	20.55	20.30	-.25				
5	30	16.82	16.98	+.16	30	21.48	22.01	+.53				
6	19	18.54	18.74	+.20	17	23.44	23.75	+.31				
7	12	20.80	20.47	-.33	10	25.12	25.46	+.34				
8	11	22.76	22.23	-.53	7	26.50	27.17	+.67				

$$T_t = 2.25N + \frac{1.32}{48}\sqrt{\left\{D + 50(N-1)\right\}\left\{D + 50(N-1) + 576\right\}}$$

TRUCKS

N	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.
1	44	13.67	14.35	+.68	99	20.73	21.56	+.83	43	25.96	27.82	+1.86
2	19	18.49	18.18	-.31	56	25.33	25.29	-.04	18	30.72	31.48	+.76
3	4	22.88	22.00	-.88	30	28.78	29.00	+.22	4	33.95	35.23	+1.28
4	2	24.20	25.80	+1.60	16	33.65	32.70	-.95				
5					8	36.68	36.40	-.28				
6					2	39.45	40.08	+.63				

TABLE 2B

RT. U.S. 1 N.B. AT AVENEL ST.

PASSENGER CARS

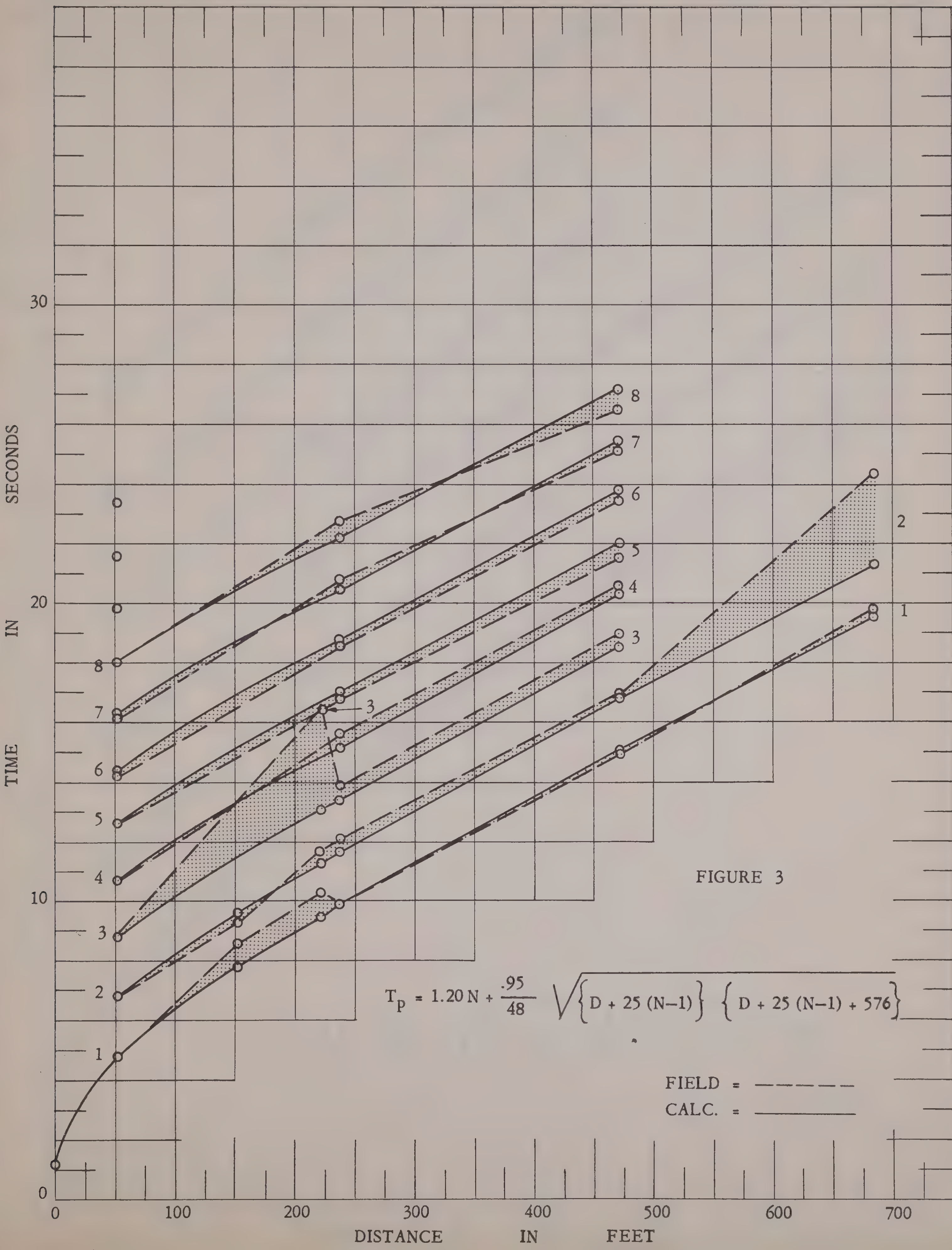


FIGURE 3

ROUTE U.S. 1, N.B., AT AVENEL ST. TRUCKS

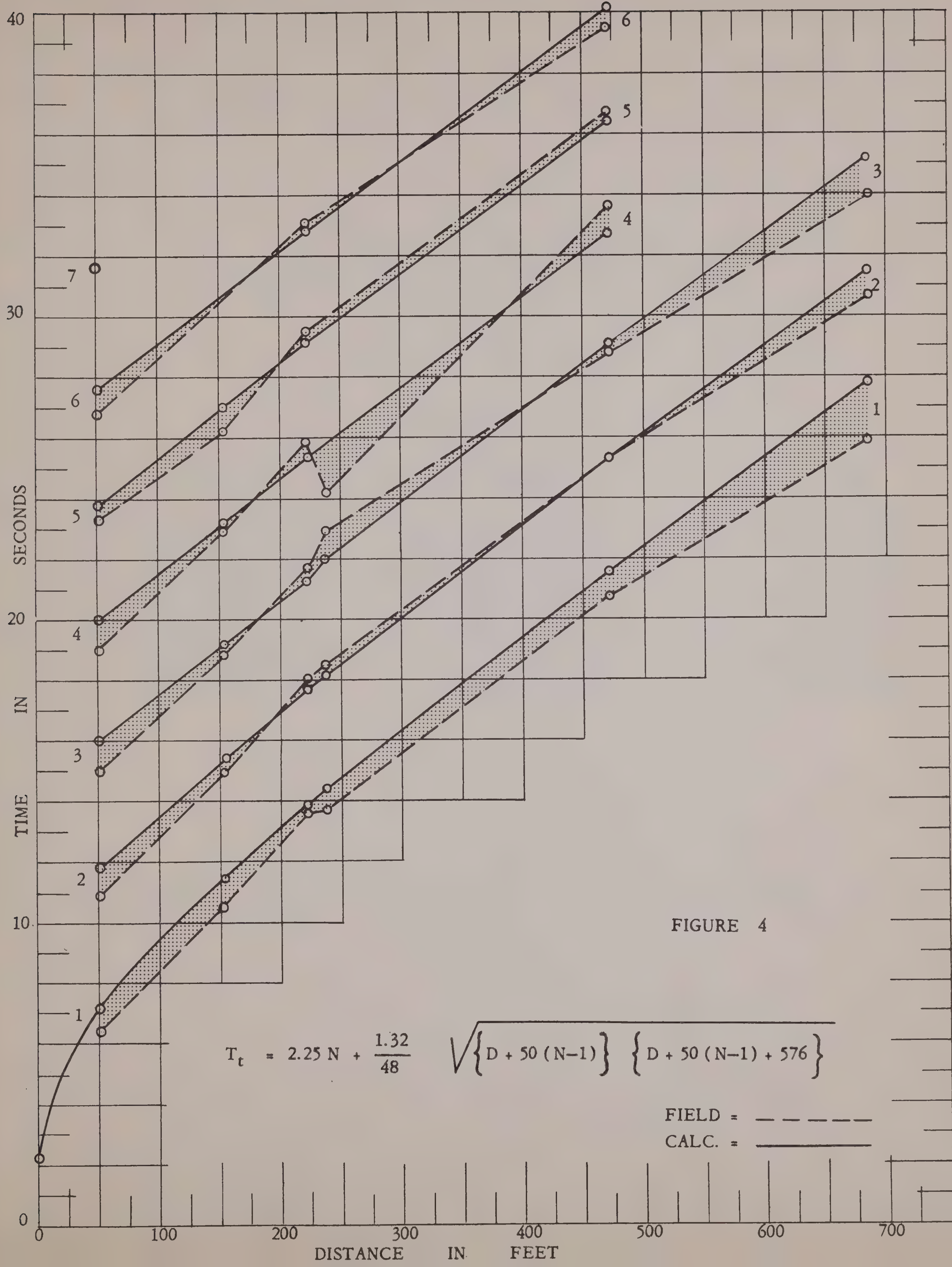


FIGURE 4

$$T_t = 2.25\,N + \frac{1.32}{48}\sqrt{\left\{D + 50\,(N-1)\right\}\left\{D + 50\,(N-1) + 576\right\}}$$

CALHOUN ST. N.B. AT INGHAM AVE.

$$T_p = 2N + \frac{.95}{29}\sqrt{\left\{D + 25(N-1)\right\}\left\{D + 25(N-1) + 210.25\right\}}$$

PASSENGER CARS

	D = 30 FEET				D = 240 FEET				D = 441 FEET			
N	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.
1	64	4.48	4.72	+.24	62	12.22	12.78	+.56	52	19.11	19.56	+.45
2	42	7.48	7.96	+.48	42	15.17	15.63	+.46	34	22.69	22.38	-.31
3	19	11.47	10.98	-.49	18	18.34	18.48	+.14	16	25.24	25.23	-.01
4	8	13.69	13.96	+.27	8	21.41	21.33	-.08	7	28.07	28.05	-.02
5	2	15.85	16.88	+1.03	2	23.45	24.28	+.83	2	30.40	30.87	+.47

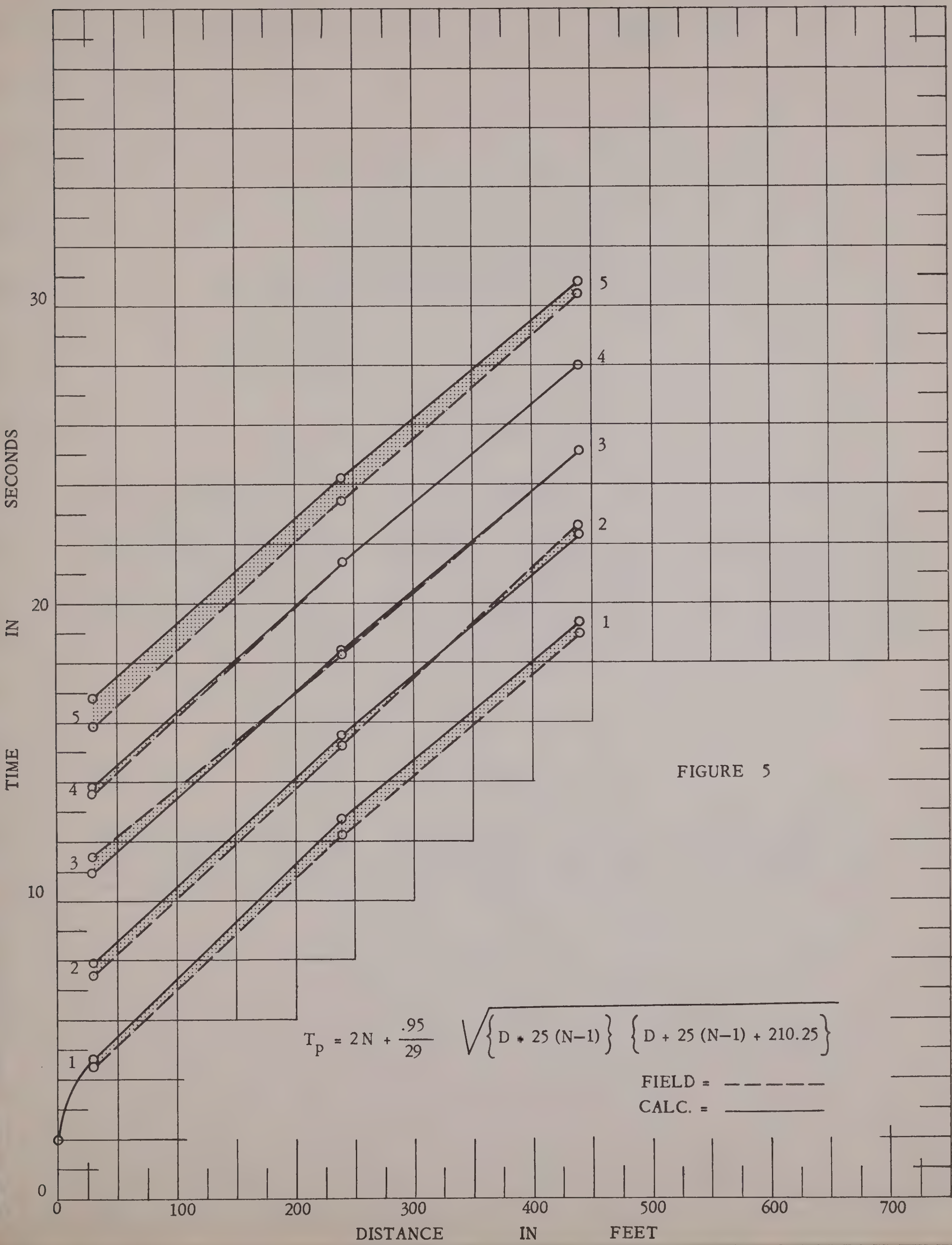
TRUCKS

1	9	4.07			8	13.96			8	22.30		

TABLE 3

CALHOUN ST. N.B. AT INGHAM AVE

PASSENGER CARS



BRUNSWICK AVE. S.B. AT OLDEN AVE

$$T_p = 2N + \frac{.95}{30}\sqrt{\left\{D + 25(N-1)\right\}\left\{D + 25(N-1) + 225\right\}}$$

PASSENGER CARS

	D = 40 FEET				D = 400 FEET				D = 485 FEET			
N	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.	Samples	Field	Calc.	Diff.
1	49	5.51	5.26	-.25	47	17.25	17.83	+.58	44	19.51	20.59	+1.08
2	21	9.19	8.34	-.85	21	20.98	20.66	-.32	20	23.40	23.38	-.02
3	11	11.99	11.32	-.67	11	23.48	23.45	-.03	10	25.90	26.20	+.30

TRUCKS

1	13	6.22			12	19.44			11	21.63		
2	4	12.25			2	22.30			2	24.55		

TABLE 4

BRUNSWICK AVE. S.B. AT OLDEN AVE.

PASSENGER CARS

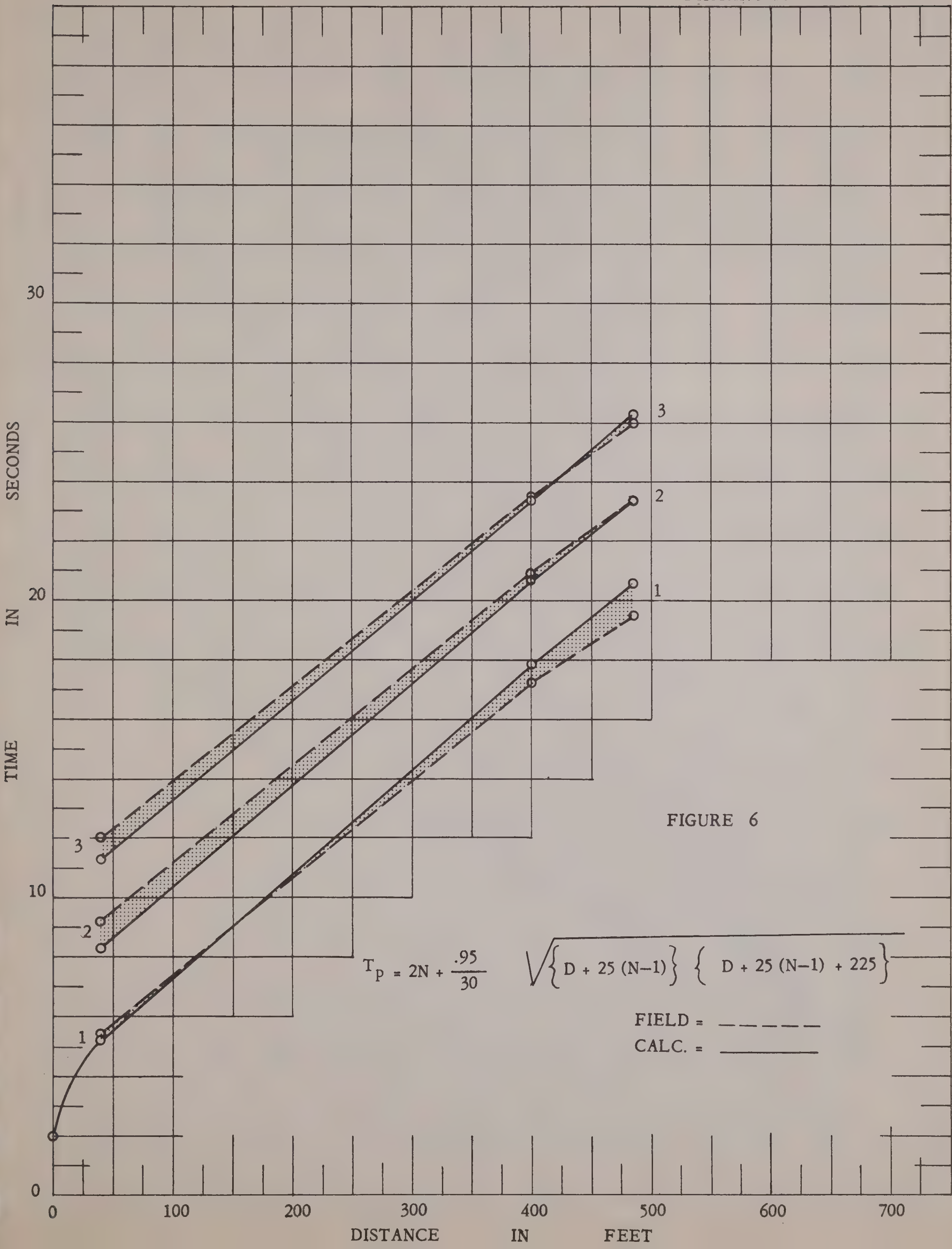
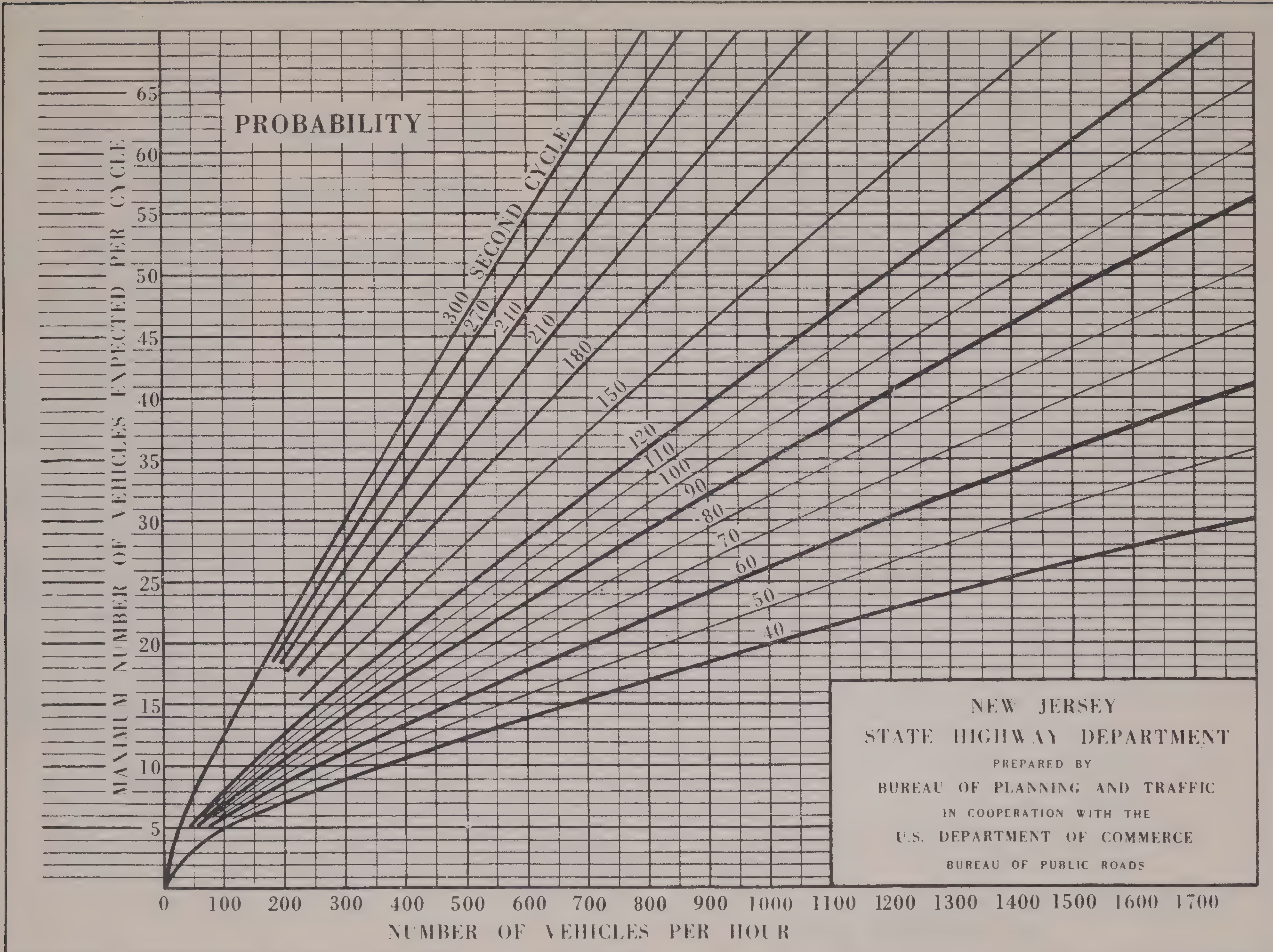


FIGURE 6


PROBABILITY
300 SECOND CYCLE
270
240
210
180
150
120
110
100
90
80
70
60
50
40
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
5
10
15
20
25
30
35
40
45
50
55
60
65
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
NUMBER OF VEHICLES PER HOUR
NEW JERSEY
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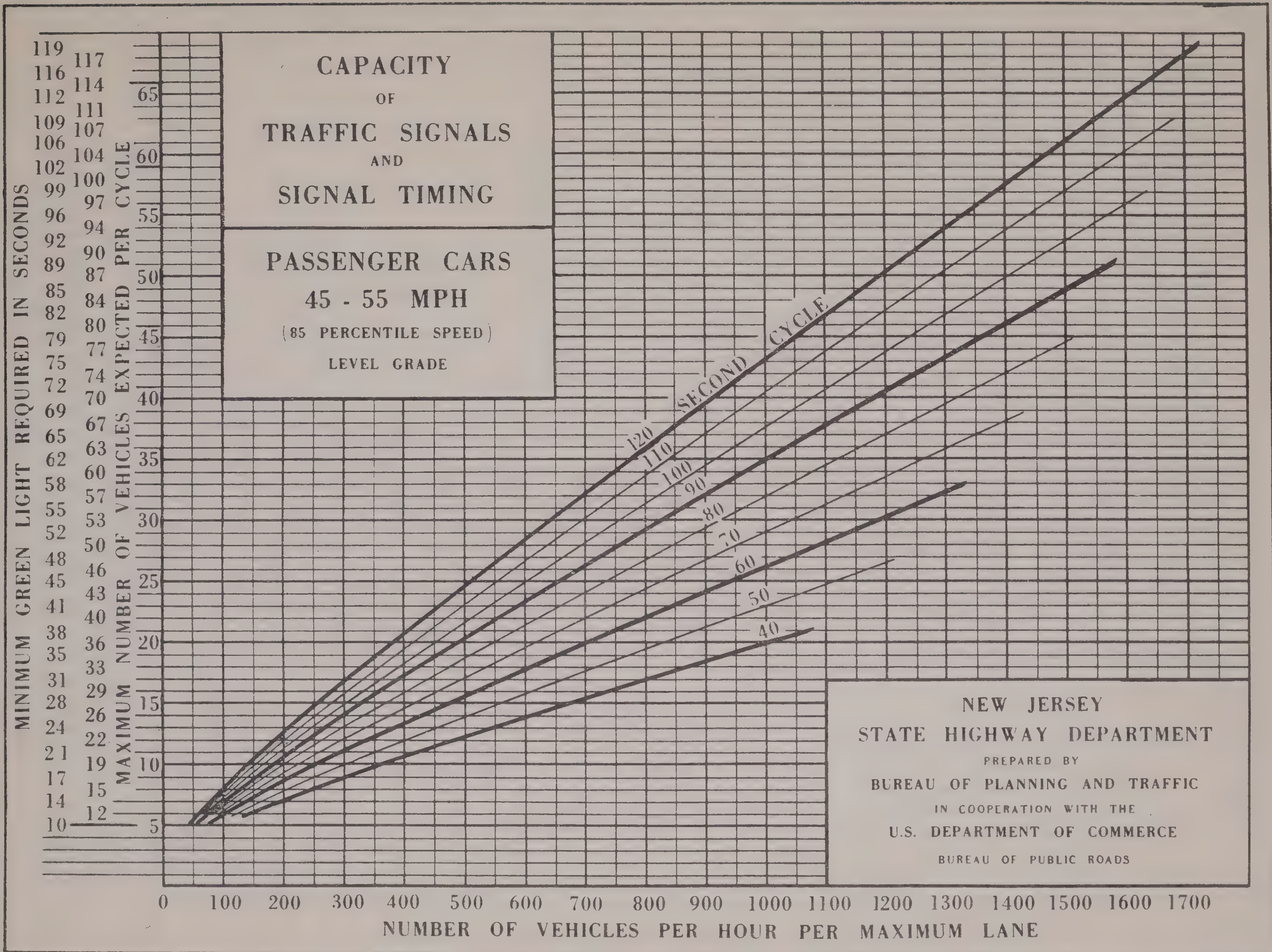
BUREAU OF PUBLIC ROADS

FIGURE 7


CAPACITY
OF
TRAFFIC SIGNALS
AND
SIGNAL TIMING
PASSENGER CARS
45 - 55 MPH
(85 PERCENTILE SPEED)
LEVEL GRADE
120 SECOND CYCLE
110
100
90
80
70
60
50
40
MINIMUM GREEN LIGHT REQUIRED IN SECONDS
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
NUMBER OF VEHICLES PER HOUR PER MAXIMUM LANE
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700
NEW JERSEY
STATE HIGHWAY DEPARTMENT
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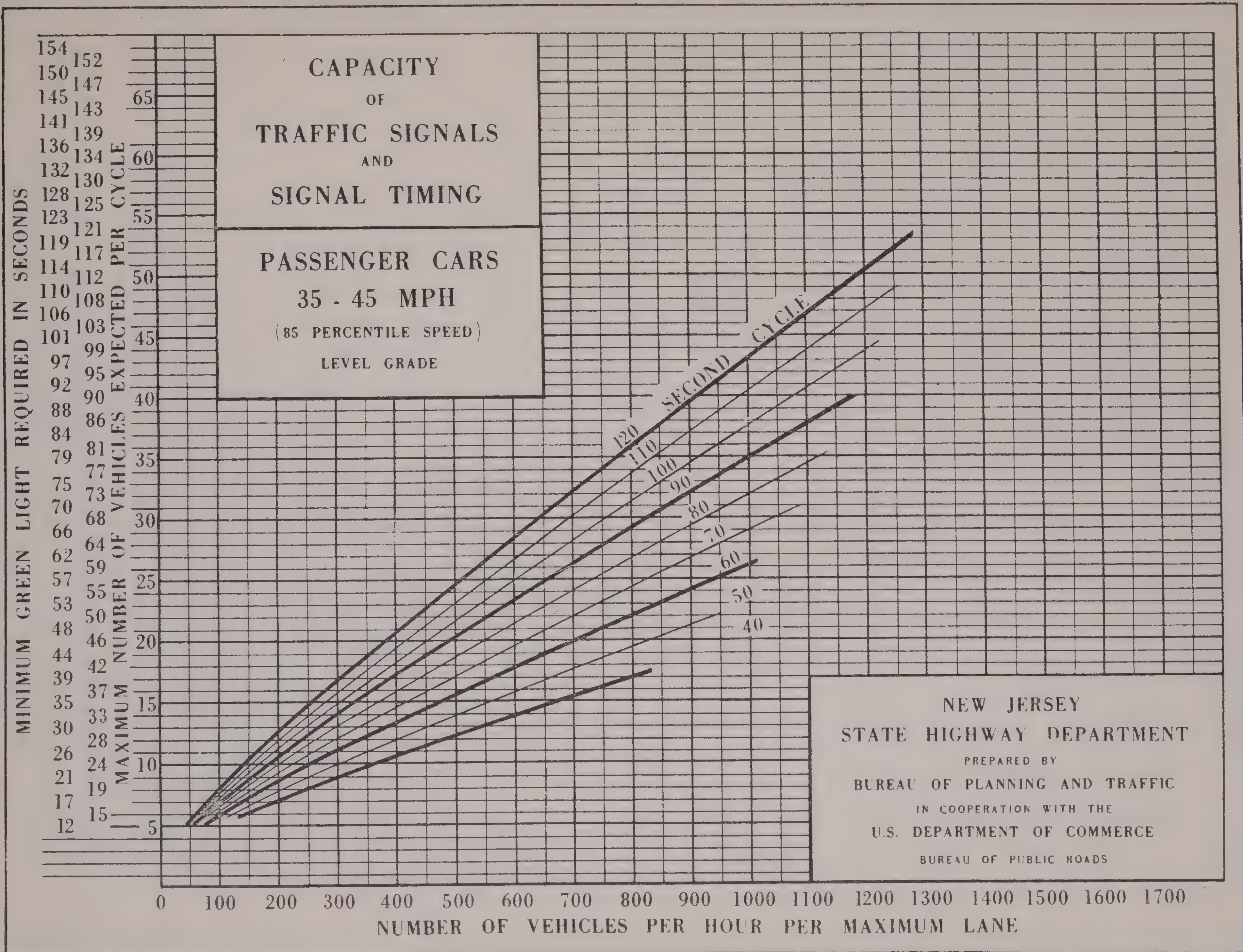
BUREAU OF PUBLIC ROADS

FIGURE 8


CAPACITY
OF
TRAFFIC SIGNALS
AND
SIGNAL TIMING
PASSENGER CARS
35 - 45 MPH
(85 PERCENTILE SPEED)
LEVEL GRADE
120 SECOND CYCLE
110
100
90
80
70
60
50
40
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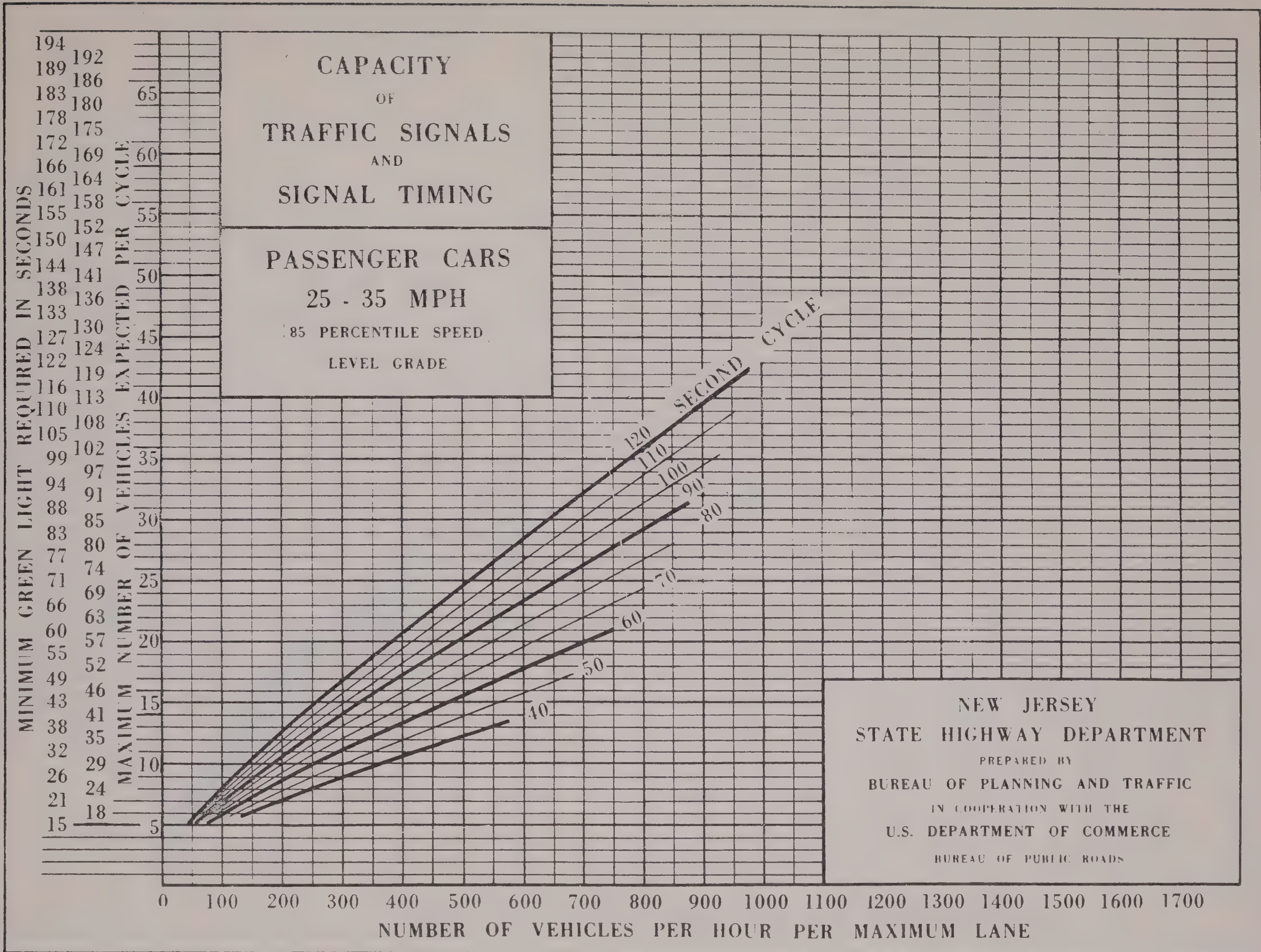
MINIMUM GREEN LIGHT REQUIRED IN SECONDS
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
NUMBER OF VEHICLES PER HOUR PER MAXIMUM LANE
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700

FIGURE 9


CAPACITY
OF
TRAFFIC SIGNALS
AND
SIGNAL TIMING
PASSENGER CARS
25 - 35 MPH
85 PERCENTILE SPEED
LEVEL GRADE
MINIMUM GREEN LIGHT REQUIRED IN SECONDS
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
194 189 183 178 172 166 161 155 150 144 138 133 127 122 116 110 105 99 94 88 83 77 71 66 60 55 49 43 38 32 26 21 15
192 186 180 175 169 164 158 152 147 141 136 130 124 119 113 108 102 97 91 85 80 74 69 63 57 52 46 41 35 29 24 18
65 60 55 50 45 40 35 30 25 20 15 10 5
120 SECOND CYCLE
110
100
90
80
70
60
50
40
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700
NUMBER OF VEHICLES PER HOUR PER MAXIMUM LANE
NEW JERSEY
STATE HIGHWAY DEPARTMENT
PREPARED BY
BUREAU OF PLANNING AND TRAFFIC
IN COOPERATION WITH THE
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
FIGURE 10

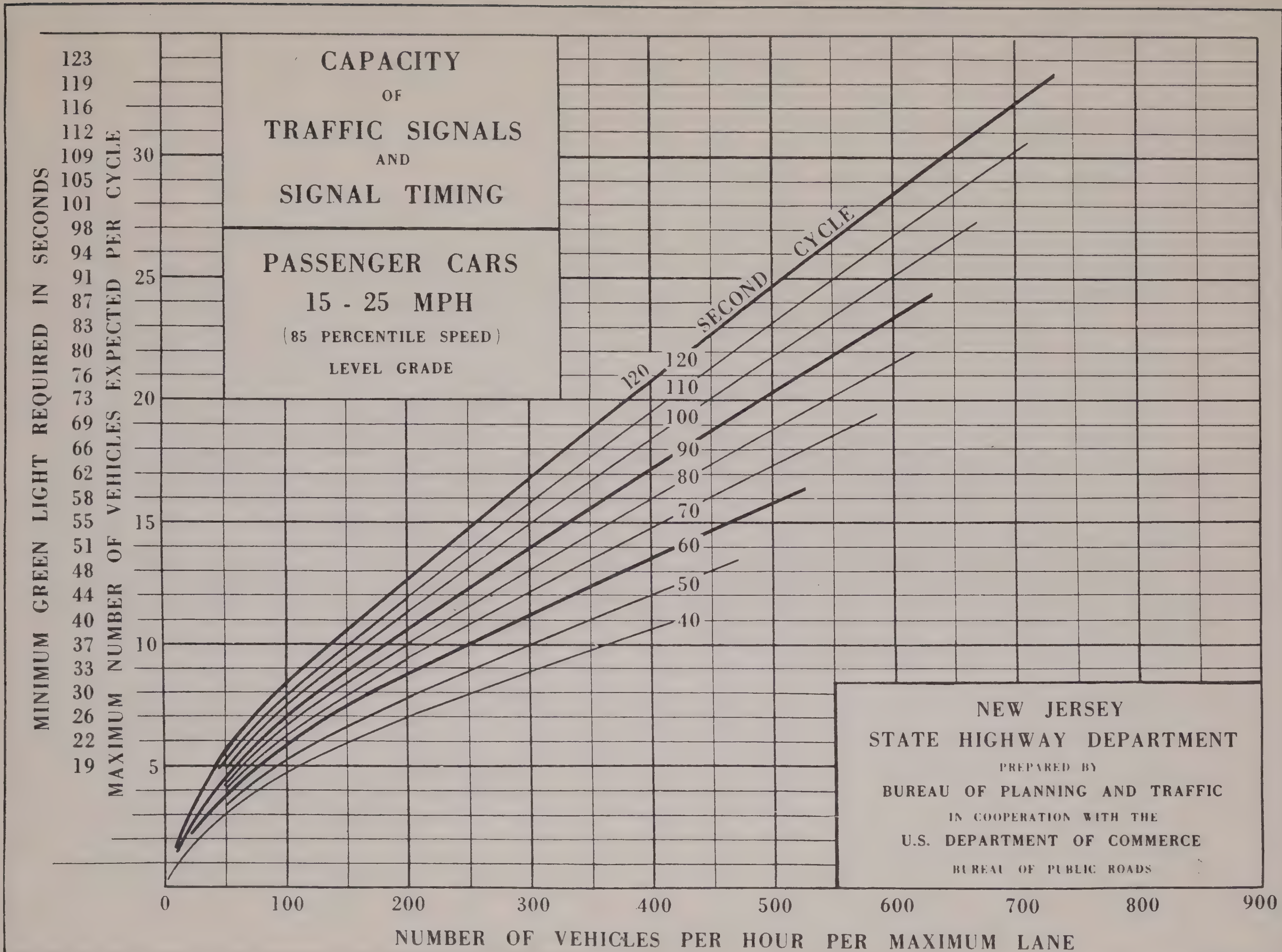
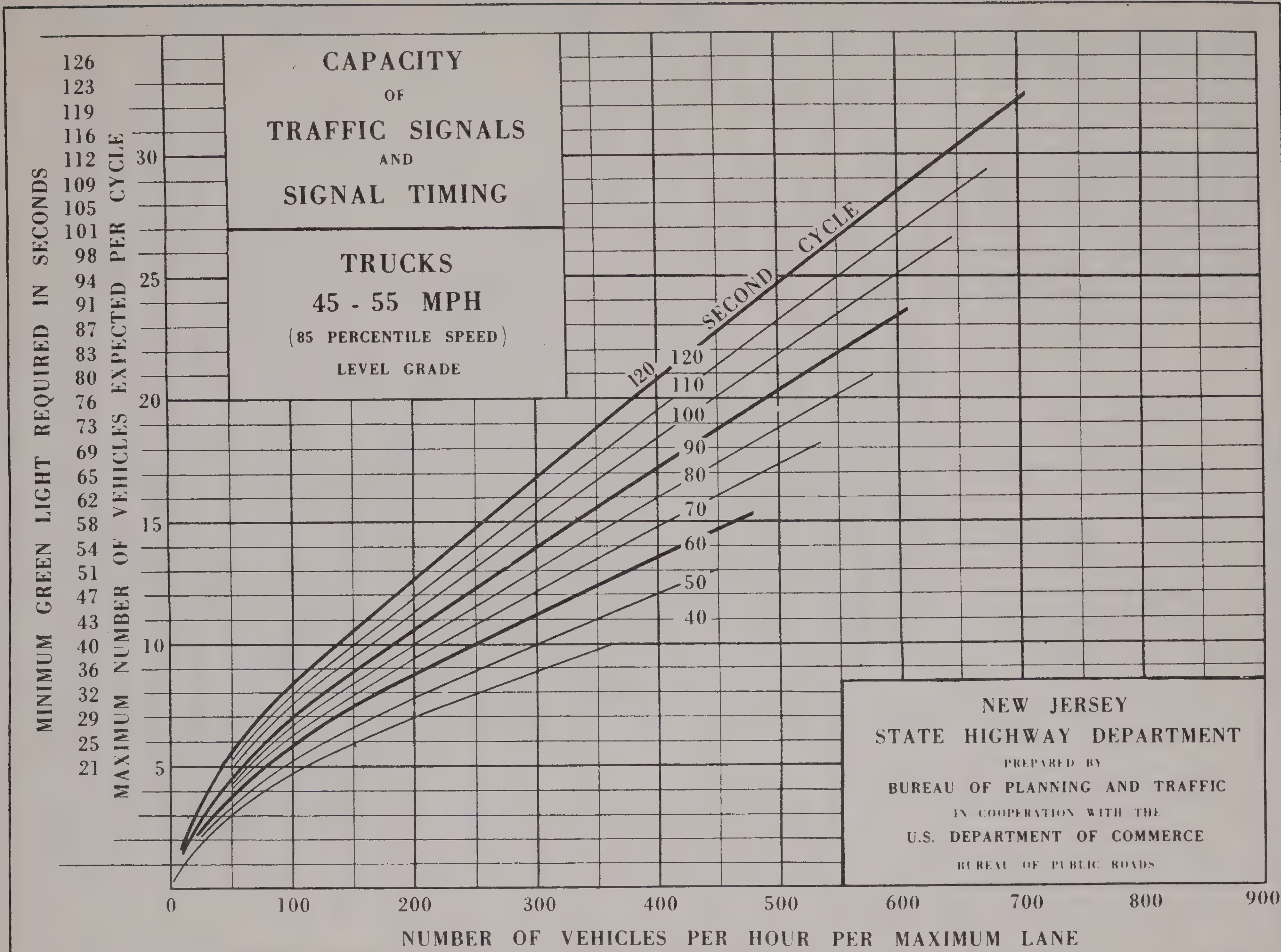

CAPACITY
OF
TRAFFIC SIGNALS
AND
SIGNAL TIMING
PASSENGER CARS
15 - 25 MPH
(85 PERCENTILE SPEED)
LEVEL GRADE
120 SECOND CYCLE
120
110
100
90
80
70
60
50
40
NEW JERSEY
STATE HIGHWAY DEPARTMENT
PREPARED BY
BUREAU OF PLANNING AND TRAFFIC
IN COOPERATION WITH THE
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
MINIMUM GREEN LIGHT REQUIRED IN SECONDS
123
119
116
112
109
105
101
98
94
91
87
83
80
76
73
69
66
62
58
55
51
48
44
40
37
33
30
26
22
19
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
30
25
20
15
10
5
0
100
200
300
400
500
600
700
800
900
NUMBER OF VEHICLES PER HOUR PER MAXIMUM LANE

FIGURE 11


CAPACITY
OF
TRAFFIC SIGNALS
AND
SIGNAL TIMING
TRUCKS
45 - 55 MPH
(85 PERCENTILE SPEED)
LEVEL GRADE
MINIMUM GREEN LIGHT REQUIRED IN SECONDS
126
123
119
116
112
109
105
101
98
94
91
87
83
80
76
73
69
65
62
58
54
51
47
43
40
36
32
29
25
21
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
30
25
20
15
10
5
120 SECOND CYCLE
120
110
100
90
80
70
60
50
40
0
100
200
300
400
500
600
700
800
900
NUMBER OF VEHICLES PER HOUR PER MAXIMUM LANE
NEW JERSEY
STATE HIGHWAY DEPARTMENT
PREPARED BY
BUREAU OF PLANNING AND TRAFFIC
IN COOPERATION WITH THE
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
FIGURE 12

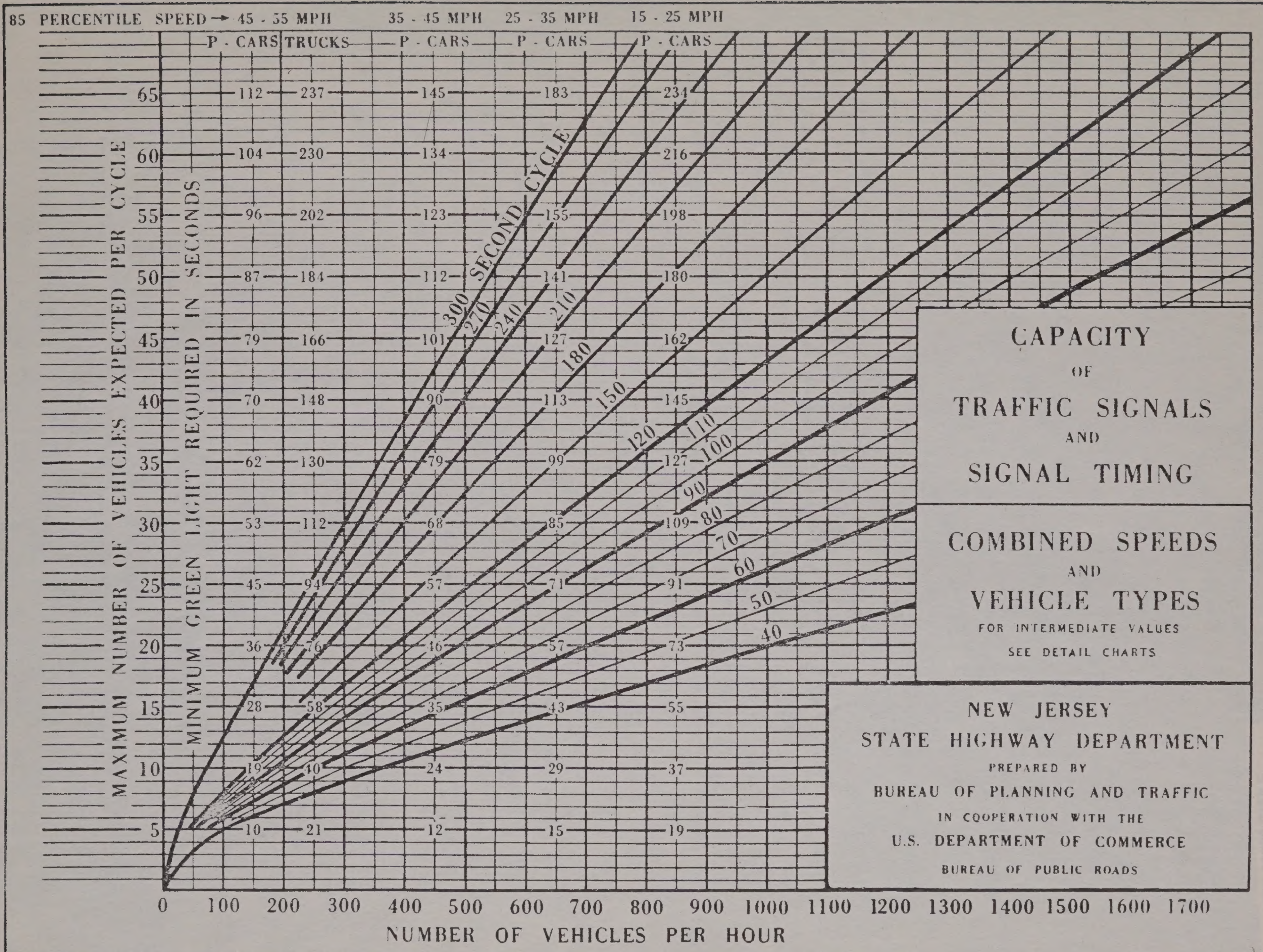

85 PERCENTILE SPEED → 45 - 55 MPH
35 - 45 MPH
25 - 35 MPH
15 - 25 MPH
P - CARS
TRUCKS
P - CARS
P - CARS
P - CARS
300 SECOND CYCLE
270
240
210
180
150
120
110
100
90
80
70
60
50
40
MAXIMUM NUMBER OF VEHICLES EXPECTED PER CYCLE
MINIMUM GREEN LIGHT REQUIRED IN SECONDS
NUMBER OF VEHICLES PER HOUR
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
CAPACITY
OF
TRAFFIC SIGNALS
AND
SIGNAL TIMING
COMBINED SPEEDS
AND
VEHICLE TYPES
FOR INTERMEDIATE VALUES
SEE DETAIL CHARTS
NEW JERSEY
STATE HIGHWAY DEPARTMENT
PREPARED BY
BUREAU OF PLANNING AND TRAFFIC
IN COOPERATION WITH THE
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

FIGURE 13